Forecasting Contracting Workload

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DLA-LO

FOREWORD

The Defense Logistics Agency (DLA) Directorate of Contracting requested DLA's Operations Research and Economic Analysis Office, DLA-LO, to investigate methods for forecasting its contracting workload which are more sensitive to the fiscal environment than currently employed techniques. An approach which attempts to forecast DLA workload from indicators of Military Service activity was chosen for this effort. This report documents and summarizes the efforts and conclusions reached in this study.

This analysis concludes DLA's contracting workload cannot be forecast directly from indicators of Service activity. However, it was possible to forecast demand for stocked items in some commodities and then to estimate the number of stock replenishment contracts using an inventory model. Unfortunately, the contracts that could be estimated in this manner represent less than half of the total number of contracts in DLA.

It is recommended that, because of the inability to uniformly forecast contracting workload from Service activity across Supply Centers, DLA continue to use its present workload forecasting techniques for the time being. However, as changes in the acquisition processes occur, we recommend that the situation be reevaluated periodically to determine if predictable relationships have emerged from the process improvements. Further, we recommend that other forecasting methodologies be explored in the future to find a technique which is more sensitive to the fiscal environment than the currently used techniques. This especially may become possible when DLA's inventory control system becomes more predictable through increased use of automation.

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EXECUTIVE SUMMARY

The recent push for a balanced Federal budget through reduced spending makes it increasingly difficult to do effective workload planning. Traditionally, workload planning has been based on historical trends in workload. But with the advent of this new pressure to reduce spending throughout the government, a different operating environment has been created. The historical trends, upon which workload planning has been based, have primarily represented periods of significant budget growth. Therefore, the use of historical trends based on the old fiscal environment may be inappropriate in forecasting workload in this new environment. Defense Logistics Agency's (DLA) Directorate of Contracting is examining alternative techniques for forecasting its contracting workload. The DLA Operations Research and Economic Analysis Office (DLA-LO) was tasked with investigating new approaches for forecasting contracting workload which did not assume the continuation of historical trends.

This study explored the possibility of forecasting DLA contracting workload from indicators of Service activity. The premise of this analysis is that DLA's contracting workload is somehow related to Service activity -- an increase in Service activity will lead to a corresponding increase in DLA workload. In this effort we examined the use of regression analysis and mathematical modeling for forecasting DLA workload.

We found that we could not forecast DLA's contracting workload directly from Service activity (given the variables we examined). We were able to forecast DLA's Supply Operations workload (expressed by item demand) from Service activity in some cases. Then, we could forecast some of DLA's stocked item contracting workload indirectly by using the forecasts of item demand. But we were unable to forecast any of DLA's non-stocked contracting workload.

Based upon the inability to accurately forecast DLA's contracting workload from Service activity, we recommend continued use of DLA's current workload forecasting techniques. We recommend that other forecasting methodologies be explored in the future to find a technique which is more sensitive to the fiscal environment than the currently used techniques. This may become possible when DLA's inventory control system becomes more predictable through increased use of automation.

I. INTRODUCTION

A. Background

In order to do meaningful workload planning and to provide defendable estimates of resource requirements to the Office of the Comptroller in the budget development process, the Defense Logistics Agency's Directorate of Contracting (DLA-P) is continually refining its workload forecasting techniques. Historically, techniques which base forecasts on the continuation of historical trends (known as time series forecasting) have been successfully employed. Times series methods ignore relationships between historical trends and external environmental factors. In general, the application of time series techniques requires the assumption that either the environment is constant, or that it is constantly (and consistently) changing.

However, with the advent of legislation to cap the Federal budget to reduce the deficit, there may be changes in DLA's fiscal environment. Forecasting methods which are sensitive to these anticipated changes may yield better forecasts than methods which are not.

B. Objective. The objective of this study was to make better forecasts of contracting workload by developing forecasting models which would take advantage of anticipated changes in the fiscal environment while avoiding the assumptions necessary for time series techniques.

II. APPROACH

Our initial approach was to directly forecast contracting workload from indicators of Service activity using regression modeling. This approach was based on the premise that as Service activity changes, DLA should experience corresponding changes in contracting workload. Because inventory theory dictates that purchasing to replenish stocks be done in an economic manner, an increase in Service activity may not necessarily lead to a corresponding increase in contracting workload. In fact, the contracting workload may not increase at all. The size of an Economic Order Quantity (EOQ) may be increased because of greater demand, but this does not necessarily imply a greater frequency of buys.

Because of this anticipated difficulty in forecasting "over" the inventory system, another method of forecasting contracting workload was explored. This method first used regression modeling to forecast demand or supply operations workload and then used a mathematical model of our automated inventory system (the Projected Supply Performance Model or PERMES) to derive the contracting workload from the forecast of demand.

III. SUMMARY OF ANALYSIS

A. Direct Forecasting of Workload

We used regression modeling in our effort to directly forecast workload from indicators of Service activity. The measures of workload that we used were:

- o Purchase Requests (PRs)
- o Purchase Request Line Items (PRLIs)
- o Item Demand
- o Requisitions

Contracting workload was measured using PRs and PRLIs. Supply operations workload was measured using item demand and requisitions. We tried to forecast these workload variables for the six commodities (Construction, Electronics, General, Industrial, Medical, and Clothing and Textiles), as well as the combined total for the first four centers (the hardware centers) and the combined total for all of the centers. We also tried to forecast the workload for only those items that were stocked and for only those that were non-stocked.

We examined three primary groups of indicators of Service activity:

- o Indicators of Equipment Usage
- o Personnel Indicators
- o Budgetary Indicators

Within each group, several actual measures were examined. For instance, indicators of equipment usage included steaming hours, flying hours, etc.; budgetary indicators included procurement dollars and operations and maintenance dollars, expressed in both constant 1987 dollars and in current dollars. See Appendix A for details. While this was not an exhaustive list of all possible indicators, we felt that this list would capture any significant change in the level of service activity. Furthermore, we discovered that, with the exception of the number of new recruits (accessions), these indicators are all highly related. If one indicator changed, then a similar change was observed in each of the other indicators.

We were unable to develop usable regression models for forecasting either of the two measures of contracting workload (PRs and PRLIs). We were able, for some commodities, to develop models to forecast demand for stocked items and to forecast demand for all items. For these models, Operations and Maintenance Dollars (in constant 1987 dollars) was found to be the best indicator. Appendix B contains the usable regression models that were developed, the uncertainty associated with each, and forecasts of the indicator variables.

We examined two measures of the uncertainty associated with these forecasting models. First, we made estimates of the size of the possible forecast error. This estimate is referred to as a "prediction interval" and it represents the bounds for the values within which the actual value of the forecast variable would be expected to fall. Another estimate of the uncertainty was made by

selecting a subset of the available observations and then developing a regression model based only on that subset of observations. This revised model was used to predict values of the forecast variable. Any differences between the predicted and actual values of the forecast variables (found in the original observations but not in the test subset) can be used to examine the consequences that could have resulted from using an actual model forecast. See Appendix B for details.

B. Indirect Forecasting Based upon Mathematical Modeling

This method used regression modeling to forecast demand or supply operations workload and then used these forecasts as input into the mathematical model PERMES. PERMES models DLA's inventory system and converts stocked item demand into standard supply statistics such as: supply availability, asset levels, and expected backorders. Two significant modifications were made to the existing PERMES, one change was to allow us to enter a demand adjustment factor and the other was to allow us to collect workload statistics.

In our examination of the forecasting error that is associated with using PERMES, we forecast 1987's contracting workload (using observed item demand for 1987) and compared it to the actual workload observed. See Appendix C for details.

This method allowed us to confidently forecast only the stocked item contracting workload for the three of the four hardware centers. See Table 1 for details.

Table 1

FORECASTS OF STOCKED ITEM PURCHASE REQUESTS FOR FY88 - FY89

Center	FY88 PRs	FY89 PRs
Construction	269,800	273,100
General	100,000	101,300
Industrial	149,400	150,700

FORECASTS OF STOCKED ITEM PRLI'S FOR FY88 - FY89

Center	FY88 PRLIs	FY89 PRLIs
Construction	337,300	341,400
General	154,000	156,000
Industrial	245,000	247,100

IV. CONCLUSIONS AND RECOMMENDATIONS

We were unable to develop a method for forecasting DLA's contracting workload **directly** from indicators of service activity. However, an **indirect** method was developed for some portions of the workload. Here, we forecast item demand (a measure of supply operations workload) and then converted the supply workload into contracting workload using a mathematical model of the Standard Automated Materiel Management System (SAMMS). This indirect approach was found to be successful for forecasting both stocked item demand and total item demand at most Supply Centers. Neither the direct nor indirect approach was successful for forecasting non-stocked item demand. Unfortunately, the non-stocked item demand generates a disproportionate share of the contracting workload and as a consequence, we were unable to develop any method of forecasting about one half of DLA's total contracting workload.

We conclude that the complexities of the inventory control system are responsible for obscuring the relationships between contracting workload and the fiscal environment.

As a result of our study, we recommend that, because of the inability to uniformly forecast contracting workload from Service activity for each of the Supply Centers, DLA continue to use its present workload forecasting techniques.

APPENDIX A

Forecast and Indicator Variable Data

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Table A-1

INDICATOR VARIABLE DATA

	1980	1981	1982	1983	1984	1985	1986	1987
Procurement Dollars (in millions)	35,310	48,025	64,462	80,355	86,161	96,842	97,282	95,777
Ops & Maint Dollars (in millions)	46,055	55,548	62,466	66,540	70,950	77,803	78,697	86,440
1987 Proc Dollars (in millions)	48,119	62,029	78,115	92,689	95,757	103,876	100,656	95,777
1987 Ops & Maint $ (in millions)	60,026	64,908	69,315	72,657	76,552	81,231	80,863	86,440
Active Duty Pers. (total number of personnel)	2,040,000	2,071,000	2,097,000	2,123,000	2,138,000	2,151,000	2,167,000	2,181,000
Reserve Personnel (total number of personnel)	823,000	917,000	975,000	1,005,000	1,046,000	1,088,000	1,135,000	1,186,000
Accessions (total number of personnel)	359,790	327,757	305,732	305,013	309,816	301,447	315,260	297,337
Army Flying Hours (total number of hours)	1,525,441	1,612,643	1,573,983	1,588,758	1,567,003	1,551,460	1,669,276	1,711,894
Navy Flying Hours (total number of hours)			2,011,077	2,096,714	2,150,416	2,097,840	2,196,243	2,302,492
AF Flying Hours (total number of hours)	3,115,430	3,233,956	3,351,727	3,402,755	3,393,746	3,481,404	3,578,586	3,643,852
Navy Steaming Hours (total number of hours)			1,176,454	1,234,688	1,321,177	1,246,986	1,203,089	1,228,104
Total Personnel (thousands of hours = 2080 * Total Personnel+ 14 * 8 * Reserves + 12 * 16 * number of reserves)	4,493,392	4,586,448	4,658,160	4,721,360	4,765,024	4,804,832	4,852,400	4,897,024
Total Flying Hours (Air Force hours plus Army hours)	4,640,871	4,846,599	4,925,710	4,991,513	4,960,749	5,032,864	5,247,862	5,355,746

Table A-2

FORECAST VARIABLE DATA

Demand

	1980	1981	1982	1983	1984	1985	1986	1987
Construction								
Non-Stocked	73,439,661	71,097,301	82,268,725	80,861,068	76,304,120	81,887,370	76,482,310	60,125,914
Stocked	61,091,692	63,332,763	68,298,390	74,482,879	79,904,021	82,891,636	74,983,616	86,061,751
Total	134,531,353	134,430,064	150,567,115	155,343,947	156,208,141	164,779,006	151,465,926	146,187,665
Electronic								
Non-Stocked	723,633	556,989	218,801	332,782	205,777	489,075	261,426	193,604
Stocked	65,938,333	69,157,868	68,773,128	67,455,832	68,079,703	77,304,232	70,357,273	63,668,473
Total	66,661,966	69,714,857	68,991,929	67,788,614	68,285,480	77,793,307	70,618,699	63,862,077
General								
Non Stocked		2,300,321	2,099,821	1,879,170	1,573,023	1,516,072	1,983,191	1,361,974
Stocked		141,392,815	145,320,767	148,522,672	154,194,860	164,916,399	155,919,431	161,430,572
Total		143,693,136	147,420,588	150,401,842	155,767,883	166,432,471	157,902,622	162,792,546
Industrial								
Non-Stocked	24,709,346	5,783,011	1,981,83	72,584,031	1,552,664	1,226,776	1,697,147	1,727,961
Stocked	612,525,707	640,919,424	675,923,571	683,725,142	710,163,655	741,962,718	700,713,915	801,147,741
Total	637,235,053	646,702,435	677,905,408	686,309,173	711,716,319	743,189,494	702,411,062	802,875,702
Hardware								
Non-Stocked		79,737,622	86,569,184	85,657,051	79,635,584	85,119,293	80,424,074	63,409,453
Stocked		914,802,870	958,315,856	974,186,525	1,012,342,239	1,067,074,985	1,001,974,235	1,112,308,537
Total		994,540,492	1,044,885,040	1,059,843,576	1,091,977,823	1,152,194,278	1,082,398,309	1,175,717,990
Medical								
Non-Stocked	698,956	655,867	571,846	679,03	801,406	972,517	1,162,943	946,226
Stocked	70,171,517	75,430,376	74,877,326	79,098,695	83,886,401	95,033,160	97,990,209	91,679,549
Total	70,870,473	76,086,243	75,449,172	79,777,731	84,687,807	96,005,677	99,153,152	92,625,775
Textile								
Non-Stocked			331,881	333,105	477,331	606,509	393,105	346,438
Stocked			200,147,497	197,641,661	196,022,389	202,297,555	212,961,823	192,265,725
Total			200,479,378	197,974,766	196,499,720	202,904,064	213,354,928	192,612,163

Table A-3

FORECAST VARIABLE DATA

Purchase Requests

	1980	1981	1982	1983	1984	1985	1986	1987
Construction								
Non-Stocked	90,532	95,156	99,717	103,704	100,705	93,124	85,661	69,059
Stocked	317,088	333,283	349,256	363,222	352,717	326,165	300,027	241,879
Total	407,620	428,439	448,973	466,926	453,422	419,289	385,688	310,938
Electronic								
Non-Stocked	35,897	36,292	35,389	34,733	36,952	35,743	29,883	30,952
Stocked	187,866	189,936	185,207	181,776	193,390	187,061	156,393	161,991
Total	223,763	226,228	220,596	216,509	230,342	222,804	186,276	192,943
General								
Non-Stocked		45,404	45,142	46,452	51,178	50,818	48,613	43,425
Stocked		116,870	116,193	119,565	131,731	130,803	125,128	111,774
Total		162,274	161,335	166,017	182,909	181,621	173,741	155,199
Industrial								
Non-Stocked	30,223	29,320	29,484	30,464	31,101	34,477	22,632	25,389
Stocked	179,808	174,434	175,408	181,238	185,029	205,115	134,644	151,049
Total	210,031	203,754	204,892	211,702	216,130	239,592	157,276	176,438
Hardware								
Non-Stocked		206,173	209,731	215,353	219,936	214,162	186,789	168,826
Stocked		814,522	826,065	845,801	862,867	849,144	716,192	666,692
Total		1,020,695	1,035,796	1,061,154	1,082,803	1,063,306	902,981	835,518

Table A-4

FORECAST VARIABLE DATA

Purchase Request Lines

	1980	1981	1982	1983	1984	1985	1986	1987
Construction								
Non-Stocked	89,071	97,343	97,017	110,299	96,619	90,566	82,303	64,272
Stocked	395,013	431,694	430,249	489,151	428,482	401,643	364,998	285,033
Total	484,084	529,037	527,266	599,450	525,101	492,209	447,301	349,305
Electronic								
Non-Stocked	37,385	38,072	36,353	35,051	38,683	39,442	31,770	31,402
Stocked	266,557	271,457	259,202	249,920	275,816	281,222	226,521	223,901
Total	303,942	309,529	295,555	284,971	314,499	320,664	258,291	255,303
General								
Non-Stocked		50,722	53,661	51,075	57,520	58,765	54,369	49,187
Stocked		184,100	194,768	185,382	208,775	213,297	197,338	178,531
Total		234,822	248,429	236,457	266,295	272,062	251,707	227,718
Industrial								
Non-Stocked	27,830	27,915	28,162	31,197	33,188	32,774	23,750	22,609
Stocked	277,998	278,842	281,307	311,626	331,513	327,376	237,235	225,838
Total	305,828	306,757	309,469	342,823	364,701	360,150	260,985	248,447
Hardware								
Non-Stocked		214,051	215,193	227,622	226,009	221,547	192,192	167,470
Stocked		1,166,094	1,165,526	1,236,079	1,244,587	1,223,538	1,026,092	913,303
Total		1,380,145	1,380,719	1,463,701	1,470,596	1,445,085	1,218,284	1,080,773

Table A-5

FORECASTS OF INDICATOR VARIABLE DATA

	1988	1989	1990
Procurement Dollars (in millions)	83,974	94,624	
Ops & Maint Dollars (in millions)	86,563	91,460	
1987 Proc Dollars (in millions)	79,521	87,003	
1987 Ops & Maint $ (in millions)	81,973	83,586	
Active Duty Pers. (total number of personnel)	2,172,000	2,184,000	
Reserve Personnel (total number of personnel)	1,190,000	1,213,000	
Accessions (total number of personnel)	270,692	283,200	297,400
Army Flying Hours (total number of hours)	1,788,341	1,809,277	1,746,275
Navy Flying Hours (total number of hours)	2,363,704	2,397,455	2,388,781
AF Flying Hours (total number of hours)	3,709,908		
Navy Steaming Hours (total number of hours)			

APPENDIX B

Regression Models and Forecasts

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Table B-1

Usable Regression Models

For Construction Stocked Item Demand:

Demand = 2,875,970 + 0.0009595 x (Ops & Maint Budget Dollars)
R-squared = .903

For General Stocked Item Demand:

Demand = 72,387,920 + 0.001062 x (Ops & Maint Budget Dollars)
R-squared = .876

For Total General Item Demand:

Demand = 77,141,414 + 0.001023 x (Ops & Maint Budget Dollars)
R-squared = .873

For Industrial Stocked Item Demand:

Demand = 237,070,290 + .006200 x (Ops & Maint Budget Dollars)
R-squared = .903

For Total Industrial Item Demand:

Demand = 290,206,565 + .005552 x (Ops & Maint Budget Dollars)
R-squared = .865

For Stocked Item Demand for all Hardware Centers:

Demand = 367,364,543 + .008402 x (Ops & Maint Budget Dollars)
R-squared = .897

For Total Item Demand for all Hardware Centers:

Demand = 493,254,288 + .007799 x (Ops & Maint Budget Dollars)
R-squared = .889

For Medical Stocked Item Demand:

Demand = 5,683,758 + .001052 x (Ops & Maint Budget Dollars)
R-squared = .833

For Total Medical Item Demand:

Demand = 5,242,794 + .001069 x (Ops & Maint Budget Dollars)
R-squared = .830

Table B-2

AVERAGE 95% PREDICTION INTERVALS

Center	Demand Type	Regressor	Average Interval
Construction	Stocked	O&M Dollars	± 11.4%
General	Stocked	O&M Dollars	± 6.3%
General	Total	O&M Dollars	± 6.0%
Industrial	Stocked	O&M Dollars	± 7.8%
Industrial	Total	O&M Dollars	± 8.3%
Hardware	Stocked	O&M Dollars	± 6.8%
Hardware	Total	O&M Dollars	± 6.2%
Medical	Stocked	O&M Dollars	± 15.1%
Medical	Total	O&M Dollars	± 15.4%

Table B-3

FORECAST OF 1987 ITEM DEMAND USING OPERATIONS AND MAINTENANCE DOLLARS

Center	Demand	Forecast	Actual	%Error
Construction	Stocked	85,656,106	86,061,751	-0.47%
General	Stocked	166,588,490	161,430,572	3.20%
General	Total	168,044,791	162,792,546	3.23%
Industrial	Stocked	754,250,518	801,147,741	-5.85%
Industrial	Total	748,252,109	802,875,702	-6.80%
Hardware	Stocked	1,077,398,159	1,112,308,537	-3.14%
Hardware	Total	1,160,177,659	1,175,717,990	-1.32%
Medical	Stocked	99,895,567	91,679,549	8.96%
Medical	Total	100,966,443	92,625,775	9.00%

Table B-4

FORECASTS OF ITEM DEMAND FOR FY88 - FY89

Stocked Demand

Center	FY88	FY89
Construction	82,000,000	83,000,000
Electronics	-	-
General	159,000,000	161,000,000
Industrial	745,000,000	755,000,000
Hardware	1,056,000,000	1,070,000,000
Medical	92,000,000	94,000,000
Textile	-	-

Total Demand

Construction	-	-
Electronics	-	-
General	161,000,000	163,000,000
Industrial	745,000,000	755,000,000
Hardware	1,133,000,000	1,145,000,000
Medical	93,000,000	95,000,000
Textiles	-	-

Table B-5

Useful Regression Models for Forecasting Requisitions

For Construction Stocked Requisitions:

Requisitions = 1,706,639 + 0.00001905 x (Procurement Budget Dollars)
R-squared = .947

For Total Construction Requisitions:

Requisitions = 1,989,152 + 0.00001697 x (Procurement Budget Dollars)
R-squared = .921

For Non-Stocked Medical Requisitions:

Requisitions = -444,364 + 0.0001042 x (Ops & Maint. Dollars)
R-squared = .893

Table B-6

AVERAGE 95% PREDICTION INTERVALS

Center	Demand Type	Regressor	Average Interval
Construction	Stocked	Procurement $	± 8.1%
Construction	Total	Procurement $	± 8.7%
Medical	Non-Stocked	O&M Dollars	± 34.7%

Table B-7

FORECAST OF 1987 REQUISITIONS

Center	Type	Regressor	Forecast	Actual	%Error
Construction	Stocked	Proc$	3,513,094	3,621,861	3.0%
Construction	Total	Proc$	3,601,857	3,675,988	2.0%
Medical	Non-Stocked	O&M$	69,136	66,571	-3.9%

Table B-8

FORECASTS OF REQUISITIONS FOR FY88 - FY89

Center	Type	FY88	FY89
Construction	Stocked	3,268,000	3,380,000
Construction	Total	3,299,000	3,407,000
Medical	Non-Stocked	61,000	64,000

APPENDIX C

PERMES VALIDATION

Forecast of Number of Contracts for FY1987

Center	Forecast Contracts	Actual Contracts	Forecast Error
Construction	95,047	86,587	+ 9.8%
Electronics	104,737	127,158	- 17.6%
General	50,175	56,817	- 11.7%
Industrial	100,966	110,584	- 8.7%
Medical	27,451	9,961	+175.6%
Textiles	6,968	8,264	- 15.6%
TOTAL	385,344	399,371	- 3.5%

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13. ABSTRACT *(Maximum 200 words)*

This study explored the possibility of forecasting DLA contracting workload from indicators of Service activity. The premise of this analysis is that DLA's contracting workload is somehow related to Service activity -- an increase in Service activity will lead to a corresponding increase in DLA workload. We examined the use of regression analysis and mathematical modeling for forecasting DLA workload. We found that we could not forecast DLA's contracting workload directly from Service activity (given the variables we examined). We were able to forecast DLA's supply operations workload (expressed by item demand) from Service activity in some cases. Then, we could forecast some of DLA's stocked item contracting workload indirectly by using the forecasts of item demand, but we were unable to forecast any of DLA's nonstocked contracting workload. Based upon the inability to accurately forecast DLA's contracting workload from Service activity, we recommend continued use of DLA's current workload forecasting techniques.

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